Potential Application of Atmospheric Water Generator (AWG) during Superfund Response Actions

Obtaining water from the atmosphere involves cooling air to below its dew point and harvesting the water that condenses on a cold surface. In spite of the energy requirements, there is an active market for AWG units with a variety of domestic and international manufacturers offering a range of products. These units range from home based units that can produce 1 to 20 liters per day to commercial scale units capable of 1,000 to 5,000 liters per day. However, these water production rates are highly dependent on the amount of water vapor (i.e., humidity) and temperature of air. Due to daily and seasonal changes, year-round continuous operation of an AWG unit is reasonable only in regions that experience consistently high water-vapor content and stable temperatures throughout the year.

The available electrically powered AWG units have stated energy consumptions ranging from 0.31 to 0.63 kWh to produce a liter of water resulting in a cost of $0.04 to $0.08 per liter of water, assuming $0.12 per kWh of electricity. Thus, AWG units may be lower cost than providing bottled water (neglecting the cost of purchasing a unit). However, compared to the cost of water from a public water supply at $0.003 per liter of water, AWG units are significantly more costly.

This technology could potentially be used as an alternative water supply during Superfund response actions in parts of the country where there is sufficient atmospheric water, however, operational costs will likely weight against its selection. Additionally, AWG units would have to be capable of providing 568 liters per day (150 gallons), which the EPA established as the minimum yield from a groundwater well in order for it to be considered as a potential source of drinking water.

An Appendix with more information is attached. It includes more background on the technology, discussion of alternative water supplies for the Superfund Program, and the applicability of AWG to a Superfund response action.

Appendix

Technology Background

In spite of the energy requirements, there is an active market for atmospheric water generator (AWG) units with a variety of domestic and international manufacturers offering a range of products. The moisture harvesting technology behind these products ranges from traditional refrigeration systems, to solar powered units, to proprietary hygroscopic-salt based units. The power source depends on the moisture harvesting technology employed with refrigeration based units requiring electrical power, others needing sufficient solar energy, and one unit does not require power (hygroscopic salt). The maturity of these units varies widely with some in early development and most of the electrically powered units being commercially available off-the-shelf.

These units range in water production capability from home based units at 1 to 20 L/day to commercial scale units at 1,000 to 5,000 L/day. However, these water production rates are highly dependent on the amount of water vapor (i.e., humidity) and temperature of air, which has been parameterized as the moisture harvesting index (Gido et al. 2016). Due to daily and seasonal changes, year-round continuous operation of an AWG unit is reasonable only in regions which experience consistently high water-vapor content and stable temperatures throughout the year (Gido et al. 2016). For the contiguous United States, cities such as New Orleans, LA and Austin, TX are examples of these regions. In cities like Tucson, AZ, operation of AWG units is possible, but atmospheric conditions favorable to yielding sufficient supply of water would have occurred only 17.8% during a 10-year time period from 2005 through 2014 (Gido et al., 2016). One AWG manufacturer provides a map showing the ideal zones for ambient water technology indicating that it is well suited for the tropics and applicable in the subtropics (Ambient Water Inc., 2015).

Although water harvested from the atmosphere has low mineral content, it may contain bacteria requiring treatment prior to consumption. Many of the commercial AWG units include filtration and oxidative treatment.

Superfund Alternative Water Supply

The 2010 OSWER Directive on providing alternative water supply as part of Superfund response actions states that alternative supply of drinking water can be provided either as a removal action or as a remedial action and may involve furnishing clean, drinkable water on a permanent or temporary basis (U.S. EPA 2010). Examples of permanent supplies of drinking water include installing a private well, connecting to a public water supply system, and drilling a new community water supply well. Temporary supplies include installing individual treatment units or delivering bottled water.

The 1988 Guidance document on providing alternate water supplies at Superfund sites contains a screening analysis of alternative sources (Figure 2-3, U.S. EPA, 1988). In the screening analysis, the preference was for a public water supply operated under the Safe Drinking Water Act. The next preference was for development of new uncontaminated groundwater sources, followed by treatment of the existing water source, and finally other available sources of uncontaminated water.

The EPA established that a groundwater well must be capable of yielding 150 gallons per day (568 liters) for a groundwater source to be considered as a potential source of drinking water to meet the needs of an average family (EPA, 1986).

In situations when public water supplies or groundwater sources are not available or deemed to not be suitable for use, then other available sources of uncontaminated water should be evaluated by considering the most cost-effective and reliable means of providing alternative sources of water.

However, the 2010 OSWER Directive cautions that if the alternative water supply will create a new public water system or expand an existing system as defined by the Safe Drinking Water Act, then the Regional EPA Drinking Water program should be consulted to ensure the owners and operators of the water systems are aware of requirements under federal, state, and local laws.

<u>Applicability of AWG as Part of Superfund Response Actions – A Site Example</u>

To illustrate how alternative water sources are evaluated during a Superfund response action, consider the recent action taken at the Ore Knob Mine Site located in Ashe County, NC, which is a region of the United States where an AWG unit is likely to provide water for a significant part of the year. In 2014, EPA Region 4 proposed an alternative water supply for 15 private wells contaminated with metals, which posed a potential risk to human health from ingestion, inhalation and dermal exposure. Region 4 considered three alternatives:

- point-of-entry treatment consisting of a household water softening unit with either bottled water or reverse osmosis treatment to supply drinking water,
- constructing a community water supply, or
- connecting residents to a local municipal water supply.

Connecting residents to the local municipal water supply was selected even though it had the largest capital cost, estimated to be from $10M to $14M, because of the long-term reliability and lowest cost to consumers, estimated to be $65 for 5,000 gallons of water per month (Black&Veatch, 2014).

The available electrically powered AWG units have stated energy consumption ranging from 0.31 to 0.63 kWh to produce a liter of water (Gido et al., 2016b). With the price of electricity at $0.12 per kWh, AWG units would cost between $704 to $1,431 to produce 5,000 gallons of water. This cost is only for the electricity to power the AWG unit and does not consider maintenance costs which are unknown at this time. Thus, it is unlikely that an AWG unit would have been selected as a long-term solution at the Ore Knob Mine Site given the monthly cost of supplying water.

However, had the public water supply option not been available, then treatment by a water softener unit along with delivery of bottled water might have been selected. For the Ore Knob Mine Site, the estimate was $250 per month to deliver 125 gallons of bottled drinking water (Black&Veatch, 2014). An AWG unit could produce this same volume of water for $18 to $36 per month in electricity cost (assumes $0.12 per kWh). In this case, an AWG unit for each home might have been a favorable option for supplying drinking water on an operational cost basis (excluding the cost of the purchasing the AWG units). Although, there was no operational cost estimated for the treatment of softened water by reverse osmosis at the Ore Knob Mine Site (Table D-7, Black&Veatch, 2014), the energy consumption of reverse osmosis (RO) ranges from 0.0025 to 0.0045 kWh to produce a liter of water, which is significantly lower than for AWG units (Gido et al. 2016a). Thus, if AWG and RO were also evaluated, RO would have lower operational cost than AWG.

References

Ambient Water Inc., 2015. Ideal Zones for Ambient Water Technology. http://www.ambientwater.com/en/markets

Black&Veatch, 2014. Engineering Evaluation/Cost Analysis for Drinking Water. SEMS 10978480.

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U.S. Environmental Protection Agency (EPA). 2010. Update on Providing Alternative Water Supply as Part of Superfund Response Actions. OSWER Directive 9355.3-22.

U.S. Environmental Protection Agency (EPA). 1988. Guidance Document for Providing Alternate Water Supplies. EPA/540/G-87/006, OSWER Directive 9355.3-03.

U.S. Environmental Protection Agency (EPA). 1986. Guidelines for Ground-Water Classification Under the EPA Ground-Water Protection Strategy. Office of Ground-Water Protection, Office of Water. November.

Select List of AWG Units

Drinkable Air Technologies
Aqua-Sciences
GR8
Ambientwater
Watair
watergen
SKYH2O
Aldelano